

Class: 12th

Subject: Physics

Chapter 16: ALTERNATING CURRENT

🔥 Important MCQs (From Key Points)

1. Alternating current is produced by a voltage source whose:

- (a) Magnitude remains constant
- (b) Polarity keeps on reversing with time
- (c) Direction never changes

(d) Resistance changes

2. The time taken by an alternating voltage to change its polarity once is called:

(a) Frequency

(b) Peak value

(c) Period

(d) Phase

3. The value of current or voltage at any instant of time is called:

(a) Average value

(b) Peak value

(c) RMS value

(d) Instantaneous value

4. The maximum value attained by an alternating current in one cycle is called:

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- (a) RMS value
 - (b) Average value
 - (c) Peak value
 - (d) Effective value

5. The sum of positive and negative peak values of AC is known as:

- (a) RMS value
- (b) Instantaneous value
- (c) Peak-to-peak value
- (d) Phase angle

6. The RMS value of an alternating current is:

- (a) Square of mean value
- (b) Mean of square values

(c) Square root of the average of square values

(d) Maximum value of current

7. The angle that specifies phase lag or phase lead is called:

(a) Frequency

(b) Phase angle

(c) Period

(d) Amplitude



8. An inductor is usually made of thick wire in order to have:

(a) Large resistance

(b) Small inductance

(c) Large self-inductance and negligible resistance

(d) No current flow

9. The combined effect of resistance and reactance is known as:

- (a) Conductance
- (b) Capacitance
- (c) Inductance
- (d) Impedance

10. The symbol used to represent impedance is:

- (a) R
- (b) X
- (c) Z
- (d) L

11. A choke is a coil having:

- (a) Thin wire and air core

(b) Thick copper wire and laminated iron core

(c) High resistance

(d) No inductance

12. A choke is used in A.C. circuits because it:

(a) Consumes large power

(b) Stores charge

(c) Limits current with small energy loss

(d) Increases voltage

13. Electromagnetic waves differ from mechanical waves because they:

(a) Require a medium

(b) Cannot travel in vacuum

(c) Need particles to propagate

(d) Do not require any medium

14. Modulation is the process of combining:

(a) Two low-frequency waves

(b) Two high-frequency waves

(c) Low-frequency signal with high-frequency carrier wave

(d) Sound waves only

15. The wave obtained after modulation is called:

(a) Carrier wave

(b) Audio signal

(c) Modulating wave

(d) Modulated carrier wave

 **Important MCQs:**

1. Alternating current is the current in which:

- (a) Direction remains constant
- (b) Magnitude remains constant
- (c) Polarity reverses with time
- (d) Frequency is zero

2. The time during which an A.C. completes one cycle is called:

- (a) Frequency
- (b) Angular frequency
- (c) Period
- (d) Phase

3. The frequency of an alternating current is given by:

- (a) $f = T$

(b) $f = 2T$

(c) $f = 1/T$ ✓

(d) $f = T^2$

4. The common source of alternating voltage is:

(a) Cell

(b) Battery

(c) A.C. generator ✓

(d) D.C. motor



5. The equation for instantaneous A.C. voltage is:

(a) $V = V_0 \cos \omega t$

(b) $V = V_0 \tan \omega t$

(c) $V = V_0 \sin \omega t$ ✓

(d) $V = IR$

6. Angular frequency (ω) is equal to:

- (a) $f/2\pi$
- (b) $1/T$
- (c) $2\pi f$ ✓
- (d) $T/2\pi$

7. At time $t = 0$, the instantaneous value of A.C. voltage is:

- (a) V_0
- (b) $-V_0$
- (c) Zero ✓
- (d) $V_0/2$

8. At $t = T/4$, the value of alternating voltage is:

- (a) Zero
- (b) Maximum (V_0) ✓

(c) RMS value

(d) $-V_0$

9. The waveform of alternating voltage is:

(a) Square

(b) Triangular

(c) Sine curve

(d) Straight line



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10. The maximum value of alternating voltage is called:

(a) RMS value

(b) Average value

(c) Peak value

(d) Instantaneous value

11. The peak-to-peak value of an A.C. voltage is:

- (a) V_0
- (b) $\sqrt{2} V_0$
- (c) $2V_0$
- (d) $V_0/2$

12. The average value of A.C. over one complete cycle is:

- (a) Maximum
- (b) RMS value
- (c) Zero
- (d) Peak value

13. RMS value of A.C. voltage is given by:

- (a) V_0
- (b) $2V_0$
- (c) $V_0/\sqrt{2}$

(d) $\sqrt{2} V_0$

14. A.C. voltmeters and ammeters are calibrated to read:

(a) Peak values

(b) Average values

(c) RMS values

(d) Instantaneous values

15. RMS value is important because it represents:

(a) Maximum voltage

(b) Zero voltage

(c) Heating effect of A.C.

(d) Frequency of A.C.

16. The phase of an alternating quantity represents:

(a) Resistance

(b) Angle defining instantaneous value

(c) Power

(d) Period

17. The phase of A.C. voltage at positive peak is:

(a) 0

(b) π

(c) $\pi/2$

(d) 2π



18. If one A.C. quantity has smaller phase than another, it is said to be:

(a) Leading

(b) Lagging

(c) In phase

(d) Opposite phase

19. Phase difference between leading and lagging A.C. quantities is conveniently shown by:

(a) Waveform

(b) Graph

(c) Vector representation

(d) Equation

20. In vector representation, an alternating quantity is shown by:

(a) Static straight line

(b) Clockwise rotating vector

(c) Counter-clockwise rotating vector

(d) Random vector

21. In A.C. circuits, current and voltage are controlled by:

-
- (a) Only resistance
 - (b) Resistance and battery
 - (c) Resistance, inductance and capacitance
 - (d) Only inductance

22. In a purely resistive A.C. circuit, the phase relation between V and I is:

- (a) Current leads voltage
- (b) Current lags voltage
- (c) Voltage and current are in phase
- (d) Phase difference is π

23. The peak value of current in a resistive A.C. circuit is given by:

- (a) $I_0 = VR$
- (b) $I_0 = V_0R$

(c) $I_0 = V_0 / R$ ✓

(d) $I_0 = R / V_0$

24. In a pure resistor connected to A.C. source, the opposition offered is called:

(a) Reactance

(b) Inductance

(c) Capacitance

(d) Resistance ✓

25. The instantaneous power in a purely resistive A.C. circuit is given by:

(a) $P = VI$

(b) $P = I^2R$

(c) $P = V^2 / R$

(d) All of these ✓

26. Alternating current flows through a capacitor because:

- (a) Plates touch each other
- (b) Dielectric allows free electrons
- (c) Plates are continuously charged and discharged
- (d) Capacitor stores current

27. In a capacitor connected to A.C. source, the phase relation is:

- (a) Voltage leads current
- (b) Current leads voltage by $\pi/2$
- (c) Voltage and current are in phase
- (d) Current lags voltage by π

28. The opposition offered by a capacitor to A.C. is called:

- (a) Resistance

(b) Inductance

(c) Capacitive reactance

(d) Impedance

29. The formula for capacitive reactance is:

(a) $X_c = 2\pi fC$

(b) $X_c = \omega C$

(c) $X_c = 1 / (2\pi fC)$

(d) $X_c = f / C$



30. Capacitive reactance is large when the frequency is:

(a) High

(b) Zero

(c) Constant

(d) Low

31. In a pure inductive A.C. circuit, the phase relation is:

- (a) Current leads voltage
- (b) Voltage and current are in phase
- (c) Current lags voltage by $\pi/2$ ✓
- (d) Voltage lags current

32. The opposition offered by an inductor to A.C. is known as:

- (a) Resistance
- (b) Capacitive reactance
- (c) Inductive reactance ✓
- (d) Impedance

33. The formula for inductive reactance is:

- (a) $X_L = 1 / (2\pi fL)$
- (b) $X_L = 2\pi fL$ ✓

(c) $X_L = L / f$

(d) $X_L = f / L$

34. Inductive reactance depends upon:

(a) Resistance only

(b) Voltage only

(c) Frequency and inductance

(d) Capacitance

35. In a pure inductor connected to A.C. source, the net power consumed in one complete cycle is:

(a) Maximum

(b) Zero

(c) Half

(d) Infinite

36. The combined effect of resistance and reactance in an A.C. circuit is called:

- (a) Resistance
- (b) Reactance
- (c) Impedance
- (d) Conductance

37. Impedance of an A.C. circuit is denoted by:

- (a) R
- (b) X
- (c) Z
- (d) L

38. Impedance (Z) is defined as the ratio of:

- (a) Peak voltage to peak current

(b) RMS voltage to RMS current

(c) Instantaneous voltage to current

(d) Average voltage to current

39. The unit of impedance is:

(a) Ampere

(b) Volt

(c) Ohm

(d) Henry

40. In an R–C series A.C. circuit, the same current flows through:

(a) Only resistor

(b) Only capacitor

(c) Both resistor and capacitor

(d) Neither of them

41. In an R–C series circuit, the voltage across resistance is:

(a) 90° ahead of current

(b) 90° behind current

(c) In phase with current

(d) Opposite to current

42. In an R–C series A.C. circuit, the current:

(a) Lags the applied voltage

(b) Is in phase with voltage

(c) Leads the applied voltage

(d) Has zero phase difference

43. The impedance of an R–C series circuit is given by:

(a) $Z = R + X_c$

(b) $Z = \sqrt{R^2 - X_C^2}$

(c) $Z = \sqrt{R^2 + X_C^2}$ ✓

(d) $Z = R - X_C$

44. In an R–L series A.C. circuit, the applied voltage:

(a) Lags the current

(b) Is in phase with current

(c) Leads the current by an angle θ ✓

(d) Is always zero

45. The impedance of an R–L series circuit is:

(a) $Z = R + XL$

(b) $Z = \sqrt{R^2 - XL^2}$

(c) $Z = \sqrt{R^2 + (\omega L)^2}$ ✓

(d) $Z = R - XL$

46. In an A.C. circuit, power is dissipated only when:

- (a) Voltage leads current by 90°
- (b) Current leads voltage by 90°
- (c) Voltage and current are in phase
- (d) Frequency is zero

47. The expression for power in an A.C. circuit is:

- (a) $P = VI$
- (b) $P = V^2/R$
- (c) $P = I^2R$
- (d) $P = V_{rms} \times I_{rms} \times \cos\theta$

48. The factor $\cos\theta$ in A.C. circuits is called:

- (a) Phase angle
- (b) Reactance

(c) Power factor

(d) Impedance

49. The power dissipation in a pure inductive or pure capacitive A.C. circuit is:

(a) Maximum

(b) Minimum

(c) Infinite

(d) Zero

50. In a series RLC circuit, resonance occurs when:

(a) $X_L > X_C$

(b) $X_L < X_C$

(c) $X_L = X_C$

(d) $R = 0$

51. The resonance frequency of a series RLC circuit is given by:

(a) $f = 2\pi\sqrt{LC}$

(b) $f = 1/(\sqrt{LC})$

(c) $f = 1/(2\pi\sqrt{LC})$ ✓

(d) $f = \sqrt{LC}/2\pi$

52. At resonance in a series RLC circuit, the impedance is:

(a) Maximum

(b) Infinite

(c) Minimum and equal to R ✓

(d) Zero

53. At resonance, the power factor of a series RLC circuit is:

(a) Zero

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- (b) Less than 1
 - (c) Greater than 1
 - (d) Equal to 1

54. At resonance in a series circuit, the current is:

- (a) Minimum
- (b) Zero
- (c) Maximum
- (d) Constant



55. At resonance, the voltage across inductor and capacitor is:

- (a) Zero
- (b) Equal to source voltage
- (c) Less than source voltage
- (d) May be greater than source voltage

56. In a parallel resonance circuit, resonance occurs when:

- (a) Branch currents are unequal
- (b) Branch currents are equal and opposite**
- (c) Supply current is maximum
- (d) Impedance is minimum

57. At resonance in a parallel L-C circuit, the impedance is:

- (a) Minimum
- (b) Zero
- (c) Maximum and resistive**
- (d) Capacitive

58. At resonance in a parallel circuit, the current drawn from supply is:

- (a) Maximum

(b) Infinite

(c) Zero

(d) Minimum

59. In a three-phase A.C. generator, the phase difference between the voltages is:

(a) 60°

(b) 90°

(c) 120°

(d) 180°



60. The main advantage of three-phase A.C. supply is that:

(a) It gives zero voltage

(b) It overloads the system

(c) Load is divided and voltage remains stable

(d) It uses only one wire

61. A metal detector works on the principle of:

(a) Resistance change

(b) Capacitance increase

(c) Change in inductance causing change in frequency

(d) Heating effect of current

62. In a metal detector, a beat note is heard because:

(a) Resistance increases

(b) Capacitance becomes zero

(c) Frequencies of two oscillators become different

(d) Voltage becomes zero

63. A choke is used in A.C. circuits to:

(a) Increase voltage

-
- (b) Store charge
 - (c) Limit current with minimum power loss
 - (d) Increase resistance

64. A choke has:

- (a) Small inductance and large resistance
- (b) Large inductance and small resistance
- (c) Equal inductance and resistance
- (d) Zero inductance

65. Electromagnetic waves can travel through:

- (a) Only solids
- (b) Only liquids
- (c) Only gases
- (d) Vacuum

66. The electric field, magnetic field and direction of propagation of an electromagnetic wave are:

- (a) Parallel to each other
- (b) In the same plane
- (c) Mutually perpendicular
- (d) Randomly oriented

67. The speed of electromagnetic waves in free space is:

- (a) 3×10^6 m/s
- (b) 3×10^8 m/s
- (c) 3×10^{10} m/s
- (d) 3×10^4 m/s

68. Electromagnetic waves are produced when electric charges:

- (a) Are at rest

(b) Move with constant velocity

(c) Are accelerated

(d) Stop moving

69. In a radio receiver, tuning is achieved by:

(a) Changing resistance

(b) Changing inductance only

(c) Changing capacitance of LC circuit

(d) Changing voltage source

70. In frequency modulation (F.M.):

(a) Amplitude of carrier changes

(b) Frequency of carrier changes with signal amplitude

(c) Both amplitude and frequency change

(d) Carrier amplitude becomes zero

🔥 Important Short Questions (From Key Points)

1. What is alternating current (A.C.)?

Answer:

👉 Alternating current is the current whose direction keeps on reversing with time.

2. What is the period of an alternating current?

Answer:

👉 The period is the time taken by an alternating current to complete one cycle.

3. What is meant by the instantaneous value of A.C.?

Answer:

👉 The value of current or voltage at any instant of time is called its instantaneous value.

4. What is the peak value of alternating voltage?

Answer:

👉 The maximum value of voltage or current in one cycle is called the peak value.

5. What is peak-to-peak value?

Answer:

👉 The sum of the positive and negative peak values of an alternating quantity is called peak-to-peak value.

6. What is RMS value of alternating current?

Answer:

👉 RMS value is the square root of the average of the squares of instantaneous values of current or voltage.

7. What is phase angle in A.C. circuit?

Answer:

👉 Phase angle is the angle that shows phase lead or phase lag between voltage and current.

8. What is an inductor?

Answer:

👉 An inductor is a coil of thick wire having large self-inductance and very small resistance.

9. What is impedance?

Answer:

👉 Impedance is the combined effect of resistance and reactance in an A.C. circuit.

10. What is a choke?

Answer:

👉 A choke is a coil of thick copper wire wound on a soft iron laminated core used to limit A.C. with little power loss.

💧 **Important Short Questions:**

1. What is alternating current (A.C.)?

Answer:

👉 Alternating current is the current produced by a voltage source whose polarity keeps on reversing with time.

2. What is the period of an A.C.?

Answer:

👉 The period is the time interval during which the voltage source changes its polarity once.

3. What is the frequency of an A.C.?

Answer:

👉 Frequency is the number of cycles of alternating current completed in one second, $f = 1/T$.

4. What is the instantaneous value of A.C.?

Answer:

👉 It is the value of voltage or current at any instant of time.

5. What is the peak value of A.C.?

Answer:

👉 The maximum value reached by the voltage or current in one cycle.

6. What is peak-to-peak value?

Answer:

👉 The sum of positive and negative peak values of A.C., written as $V_{p-p} = 2V_0$.

7. What is RMS value of an A.C.?

Answer:

👉 RMS value is the square root of the average of squares of instantaneous values over a cycle.

8. What is meant by phase of A.C.?

Answer:

👉 Phase is the angle which specifies the instantaneous value of alternating voltage or current.

9. What is phase lead and phase lag?

Answer:

👉 Phase lead occurs when one A.C. quantity is ahead of another; phase lag occurs when it is behind.

10. How is an alternating quantity represented vectorially?

Answer:

👉 By a rotating vector whose length represents the peak or RMS value and rotates with angular frequency.

11. What is the basic circuit element in a D.C. circuit?

Answer:

👉 The basic circuit element in a D.C. circuit is a resistor (R), which controls the current or voltage.

12. Which additional elements become relevant in an A.C. circuit besides a resistor?

Answer:

👉 In A.C. circuits, an inductor (L) and a capacitor (C) become relevant along with a resistor (R).

13. How does current behave in a purely resistive A.C. circuit?

Answer:

👉 In a purely resistive A.C. circuit, the instantaneous values of voltage and current are in phase, rising and falling together.

14. What is Ohm's law for an A.C. resistor?**Answer:**

👉 Ohm's law for a resistor in an A.C. circuit is $V = I \times R$, where V and I are instantaneous values.

15. What is the instantaneous power in a resistor?**Answer:**

👉 The instantaneous power in a resistor is $P = I^2 \times R = V \times I = V^2 / R$, valid when voltage and current are in phase.

16. How does A.C. flow through a capacitor?**Answer:**

👉 A.C. flows through a capacitor because the capacitor plates are continuously charged and discharged by the alternating voltage.

17. What is the phase relationship between current and voltage in a capacitor?

Answer:

👉 In a capacitor, the current leads the applied voltage by 90 degrees ($\pi/2$).

18. What is capacitive reactance?

Answer:

👉 Capacitive reactance (X_c) is the opposition offered by a capacitor to the flow of A.C., calculated as $X_c = 1 / (2\pi fC)$.

19. What is the phase relationship between current and voltage in an inductor?

Answer:

👉 In an inductor, the current lags behind the applied voltage by 90 degrees ($\pi/2$), or the voltage leads the current by 90 degrees.

20. What is inductive reactance and how does it depend on frequency?

Answer:

👉 Inductive reactance (X_L) is the opposition offered by an inductor to A.C., given by $X_L = 2\pi fL$. It is directly proportional to both frequency (f) and inductance (L).

21. Define impedance in an A.C. circuit.

Answer:

👉 Impedance (Z) is the total opposition offered by resistance and reactances (inductive and capacitive) to the flow of alternating current.

22. How is impedance (Z) of an A.C. circuit calculated?

Answer:

👉 Impedance is the ratio of rms voltage to rms current:

$$Z = V_{rms} / I_{rms}$$

23. What is the phase difference in a series R-C circuit?

Answer:

👉 In a series R-C circuit, current leads the applied voltage by an angle θ , where $\theta = \arctan(X_c / R)$

24. Write the formula for impedance in a series R-C circuit.

Answer:

👉 $Z = \sqrt{R^2 + (1 / \omega C)^2}$

25. What is the phase difference in a series R-L circuit?

Answer:

👉 In a series R-L circuit, voltage leads the current by an angle θ , where $\theta = \arctan(\omega L / R)$

26. Write the expression for power in an A.C. circuit.

Answer:

👉 $P = I_{\text{rms}} \times V_{\text{rms}} \times \cos \theta$

($\cos \theta$ is the power factor)

27. What is power factor in an A.C. circuit?

Answer:

👉 Power factor is the cosine of the phase angle θ between voltage and current: $\cos \theta$.

28. What is series resonance in an RLC circuit?

Answer:

👉 Series resonance occurs when inductive reactance X_L equals capacitive reactance X_C , i.e., $X_L = X_C$.

29. Write the formula for resonance frequency in a series RLC circuit.

Answer:

👉 $f_r = 1 / (2\pi \sqrt{LC})$

30. What happens to impedance at series resonance?

Answer:

👉 Impedance is minimum and equal to R; current is maximum; voltage and current are in phase; power factor is 1.

31. What is parallel resonance in an L-C circuit?

Answer:

👉 Parallel resonance occurs when the currents in the inductor and capacitor branches are equal and opposite, resulting in minimum supply current.

32. Write the properties of a parallel resonant circuit.

Answer:

- 👉 (i) Impedance is maximum
- 👉 (ii) Current drawn from supply is minimum
- 👉 (iii) Voltage and current are in phase; power factor is 1
- 👉 (iv) Branch currents may be larger than supply current

33. How is capacitance calculated for a resonance circuit of known frequency and inductance?

Answer:

👉 $C = 1 / (4\pi^2 f^2 L)$

34. What is a three-phase A.C. supply?

Answer:

👉 A three-phase supply has three coils generating voltages 120° apart, producing three alternating voltages.

35. What are the advantages of a three-phase supply over single-phase?

Answer:

- 👉 (i) Load is divided into three parts, avoiding overload
- 👉 (ii) Provides stable voltage for heavy appliances
- 👉 (iii) Line-to-line voltage is higher (e.g., 400 V) for special equipment

36. What is the principle of a metal detector?

Answer:

- 👉 A metal detector uses two L-C oscillators. When a metal object comes near the search coil, its inductance changes, altering the oscillator frequency and producing a beat note in a speaker.

37. What is a choke and its use in A.C. circuits?

Answer:

👉 A choke is a coil of thick copper wire with large inductance and small resistance, used to limit A.C. current with minimal energy loss.

38. What are electromagnetic waves?

Answer:

👉 Electromagnetic waves are moving electric and magnetic fields that propagate through space without any medium, at the speed of light (3×10^8 m/s).

39. How are electromagnetic waves generated and received?

Answer:

👉 Generated by accelerating charges in a transmitting antenna; received by electrons in a receiving antenna, where alternating voltage of the same frequency is induced.

40. What is modulation and its types?

Answer:

👉 Modulation is the process of combining a low-frequency signal with a high-frequency carrier wave.

Types:

1. Amplitude Modulation (A.M.) – Carrier wave amplitude varies with the signal.
2. Frequency Modulation (F.M.) – Carrier wave frequency varies with the signal; amplitude remains constant.

💧 Important long questions:

🌟 Q.1: Define alternating current (A.C.) and explain its waveform with a diagram.

❖ Answer:**1. Definition:**

Alternating current (A.C.) is a current that reverses its direction periodically. Unlike D.C., it continuously changes direction with time.

2. Waveform Equation:

Instantaneous voltage:

- $V = V_0 \times \sin(\omega t)$

Instantaneous current:

- $I = I_0 \times \sin(\omega t)$

Where:

V_0 = Peak voltage, I_0 = Peak current, ω = Angular frequency

3. Angular Frequency:

- $\omega = 2 \pi f$
- f = frequency of A.C.
- T = period of A.C., $f = 1 / T$

4. Positive and Negative Half-Cycles:

- **Positive half-cycle:** 0 to $T/2$ → Current flows in one direction, voltage is positive
- **Negative half-cycle:** $T/2$ to T → Current reverses direction, voltage is negative

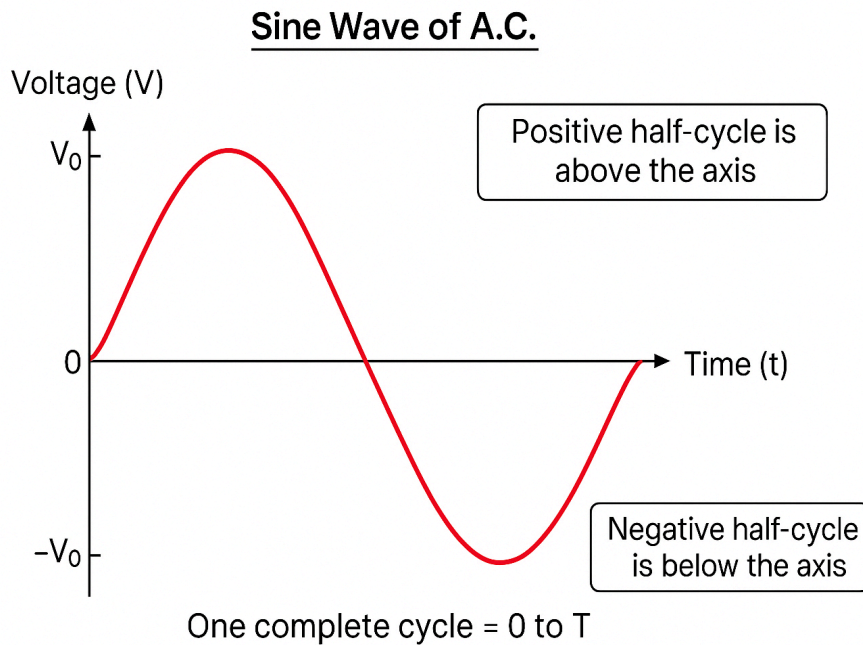
5. Peak-to-Peak Value:

- $V(p-p) = 2 \times V_0$

6. RMS Value:

- **Effective voltage:** $V(\text{rms}) = V_0 / \sqrt{2}$
- **Effective current:** $I(\text{rms}) = I_0 / \sqrt{2}$

◆ Diagram (Sine Wave of A.C.):



◆ **Summary:**

- A.C. reverses direction periodically.
- The waveform is sinusoidal.

Key properties: period (T), frequency ($f = 1/T$), peak value (V_0), RMS value ($V(\text{rms})$).

☀ **Q.2: What is instantaneous value, peak value, peak-to-peak value, and RMS value of A.C.? Explain with formulas.**

❖ **Answer:**

Alternating Current (A.C.) varies continuously with time, changing its magnitude and direction. To describe it mathematically, we use several values: instantaneous, peak, peak-to-peak, and RMS.

1. Instantaneous Value (i or v)

- The instantaneous value of A.C. at any time t is the actual value of current or voltage at that instant.
- **It changes** continuously over a cycle.

For sinusoidal A.C., the instantaneous voltage is:

$$V = V_0 \times \sin(\omega t)$$

Where:

- V_0 = Peak voltage
- ω = Angular frequency = $2\pi f$
- t = Time

Similarly, the instantaneous current is:

$$I = I_0 \times \sin(\omega t)$$

2. Peak Value (V_0 or I_0)

- The peak value is the maximum value of voltage or current in one cycle.

For a sinusoidal waveform:

- V_0 = Maximum voltage
- I_0 = Maximum current

3. Peak-to-Peak Value (V_{p-p} or I_{p-p})

- The peak-to-peak value is the total difference between positive and negative peaks.

Formula:

$$V_{p-p} = 2 \times V_0$$

$$I_{p-p} = 2 \times I_0$$

4. Root Mean Square (RMS) Value (V_{rms} or I_{rms})

- RMS value represents the effective value of A.C., i.e., the value of direct current that would produce the same heating effect in a resistor.

For a sinusoidal waveform:

- $V_{rms} = V_0 / \sqrt{2} \approx 0.707 \times V_0$
- $I_{rms} = I_0 / \sqrt{2} \approx 0.707 \times I_0$

RMS values are what most A.C. meters display.

◆ Summary:

- **Instantaneous value:** Value at a specific instant, $V = V_0 \sin(\omega t)$
- **Peak value:** Maximum value, V_0 or I_0
- **Peak-to-peak value:** Total swing, $2V_0$ or $2I_0$

-
- **RMS value:** Effective value, $V_{r.m.s.} = V_0/\sqrt{2}$, $I_{r.m.s.} = I_0/\sqrt{2}$

★ **Q.3: Explain the concept of phase, phase lead, and phase lag in A.C. circuits. Define phase and phase difference (angle θ). Illustrate using waveform diagrams.**

❖ **Answer:**

Phase in A.C. Circuits:

Phase describes the relative position of an alternating quantity (voltage or current) at any instant of time with respect to a reference.

1. Phase and Phase Difference:

- The phase of an alternating quantity is the angle θ that specifies its instantaneous value at a particular time.
- The phase difference between two A.C. quantities is the difference in their phases, denoted by θ . It tells whether one quantity is ahead or behind the other.

Mathematical Representation:

Instantaneous value of reference voltage:

- $V = V_0 * \sin(\omega t)$

Instantaneous value of another quantity:

- $V' = V_0 * \sin(\omega t + \theta)$

Here, θ is the phase difference.

2. Phase Lead and Phase Lag:

Phase Lead: When an A.C. quantity reaches its maximum before the reference, it leads the reference.

- **Example:** $V = V_0 * \sin(\omega t + \pi/2) \rightarrow$ Voltage leads current by 90° .

Phase Lag: When an A.C. quantity reaches its maximum after the reference, it lags the reference.

- **Example:** $I = I_0 * \sin(\omega t - \pi/2) \rightarrow$ Current lags voltage by 90° .

3. Waveform Illustration:

- Horizontal axis → Time (t)
- Vertical axis → Voltage/Current
- Solid sine wave → reference A.C.
- Dashed sine wave → leads or lags by θ .

Label θ as the phase difference between the two waves.

✨ **Q.4: Explain the behavior of a pure inductor in an AC circuit. Show the relationship between voltage and current with a diagram.**

❖ **Answer:**

1. Definition of a Pure Inductor:

A pure inductor is a coil of wire with negligible resistance and high self-inductance (L). Its main property is to oppose any change in the current flowing through it. This opposition is due to the back emf induced in the coil.

2. Behavior in an AC Circuit:

When an alternating voltage (AC) is applied across a pure inductor:

- The inductor opposes the change in current continuously because the current is constantly changing in an AC circuit.
- **As a result**, the current lags behind the applied voltage by 90° ($\pi/2$ radians).
- **Equivalently**, the voltage leads the current by 90° .

3. Mathematical Expression:

Let the current through the inductor be:

$$I(t) = I_0 * \sin(\omega t)$$

where:

- I_0 = peak current
- $\omega = 2\pi f$ = angular frequency of AC
- t = time

The instantaneous voltage across the inductor is given by Faraday's law:

$$V(t) = L * dI/dt$$

Substituting the current:

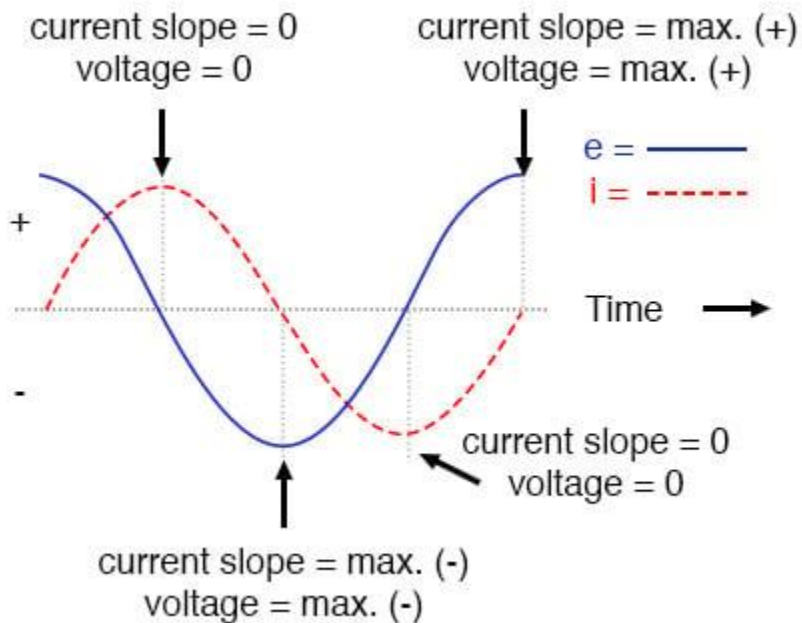
- $V(t) = L * d/dt [I_0 * \sin(\omega t)]$
- $V(t) = L * I_0 * \omega * \cos(\omega t)$
- $V(t) = V_0 * \cos(\omega t)$

where $V_0 = \omega * L * I_0$ is the peak voltage.

Observation:

- Voltage waveform is ahead of current by 90° .
- The current waveform is behind voltage by 90° .

Digram:



5. Inductive Reactance:

The opposition offered by the inductor to AC is called inductive reactance (X_L):

$$X_L = V_0 / I_0 = \omega * L = 2 * \pi * f * L$$

- f = frequency of AC
- L = inductance of the coil

6. Power in a Pure Inductor:

Instantaneous power:

$$P(t) = V(t) * I(t) = V_0 * I_0 * \sin(\omega t) * \cos(\omega t)$$

- Over one complete cycle, net power is zero. Energy is alternately stored in the magnetic field and then returned to the circuit, so a pure inductor does not consume power.

🌟 **Q.5: Explain the construction and working of a three-phase AC generator. Draw a labeled diagram.**

❖ **Answer:**

A three-phase AC generator is a device that converts mechanical energy into electrical energy in the form of three alternating voltages, each separated by a phase difference of 120° . It is commonly used in power generation and industrial applications.

Construction:

1. It consists of three separate coils (armatures) wound on the stator or rotor.

2. The coils are mechanically positioned at 120° to each other, ensuring phase separation of generated voltages.
3. Each coil is connected to a pair of slip rings that allows the AC voltage to be drawn externally.
4. The starting points of all coils are connected to a common neutral point, while the other ends are connected to three separate terminals labeled A, B, and C.

Working:

1. When the rotor or coils rotate in a magnetic field, an alternating voltage is induced in each coil due to electromagnetic induction.
2. Since the coils are at 120° to each other, the voltages produced by each coil reach their maximum at different times, producing three sinusoidal voltages out of phase by 120° .
3. These voltages can be taken from either line-to-neutral (phase voltage, 230 V) or line-to-line (line voltage, 400 V) connections.

Phase Difference:

- The three voltages have the same amplitude and frequency, but each lags or leads the others by 120° .
- This ensures smooth and continuous power supply, reduces voltage drops, and allows the load to be evenly shared among the three phases.

Advantages:

1. Provides constant power transfer, unlike single-phase AC.
2. Reduces voltage drops when supplying heavy loads.
3. Allows operation of high-power equipment like motors, air conditioners, and industrial machinery.

 **Q.6: Explain electromagnetic waves, their generation, transmission, reception, and modulation.**

❖ **Answer:**

Electromagnetic Waves:

Electromagnetic waves (EM waves) are waves consisting of oscillating electric and magnetic fields that propagate through space without requiring any medium. The electric field, magnetic field, and the direction of wave propagation are mutually perpendicular to each other.

The speed of EM waves in free space is given by:

$$c = \lambda * f$$

- where $c = 3 \times 10^8$ m/s, λ is wavelength, and f is frequency.

Generation of Electromagnetic Waves:

EM waves are generated by accelerating charges. A simple example is a transmitting antenna, where an alternating voltage is applied:

- The top of the antenna gets positive charge, then negative, repeatedly.
- This creates a changing electric flux, which generates a magnetic field.

-
- The changing magnetic flux in turn generates an electric field.
 - These mutually changing fields propagate as electromagnetic waves in space.

Resonance of receiving antenna:

To receive waves efficiently, the antenna is connected to an LC circuit tuned to the transmitting frequency:

$$f = 1 / (2 * \pi * \text{sqrt}(L * C))$$

where L = inductance and C = capacitance.

Transmission of Electromagnetic Waves:

- The transmitted EM wave carries energy through space at the speed of light.

Each wave has a frequency (f) and wavelength (λ) related by:

$$c = \lambda * f$$

Reception of Electromagnetic Waves:

- When EM waves reach a receiving antenna, the oscillating electric field moves electrons in the wire, producing an alternating voltage.
- The LC circuit in the receiver is tuned to resonate at the wave's frequency, selecting the desired signal.

Modulation:

- To transmit information (like sound or video), the low-frequency message signal is impressed on a high-frequency carrier wave. This is called modulation.

1. Amplitude Modulation (A.M.):

The amplitude of the carrier varies according to the message signal:

$$V_{AM} = V_c * [1 + m * \sin(2 * \pi * f_m * t)] * \sin(2 * \pi * f_c * t)$$

where V_c = carrier amplitude, f_c = carrier frequency, f_m = message frequency, m = modulation index.

2. Frequency Modulation (F.M.):

The frequency of the carrier varies according to the message signal:

$$V_{\text{FM}} = V_{\text{c}} * \sin[2 * \pi * f_{\text{c}} * t + k_{\text{f}} * \sin(2 * \pi * f_{\text{m}} * t)]$$

where k_{f} = frequency sensitivity constant.

◆ **Summary:**

- EM waves are self-propagating oscillations of electric and magnetic fields.
- Generated by accelerating charges in a transmitting antenna.
- Received by a tuned receiving antenna.
- Modulation (A.M. or F.M.) allows transmission of audio, video, or data over long distances.

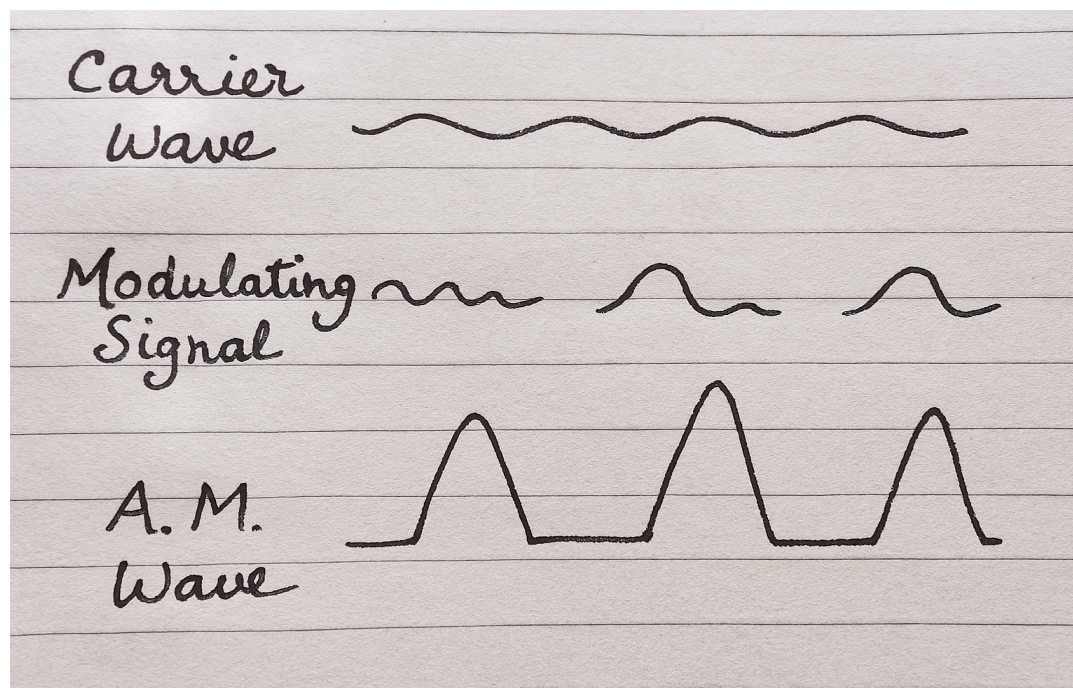
✦ **Q.7: Explain amplitude modulation (A.M.) with a diagram.**

❖ **Definition:**

Amplitude Modulation (A.M.) is the process in which the amplitude of a high-frequency carrier wave is varied according to the instantaneous amplitude of a low-frequency modulating signal (such as speech or music), while the

frequency of the carrier remains constant. The resulting wave is called an amplitude-modulated wave.

◆ Digram:



Working Concept:

- 1. Carrier Wave:** A high-frequency wave of constant amplitude.
- 2. Modulating Signal:** A low-frequency wave representing audio or information.
- 3. Modulated Wave:** The carrier's amplitude changes in accordance with the modulating signal. The envelope of the A.M. wave represents the original information.
 - **Typical A.M. Transmission Range:** 540 kHz – 1600 kHz.

💧 Exercise Questions:

🌟 16.1 A sinusoidal current has rms value of 10A. What is the maximum or peak value?

❖ Answer:

Step 1: Understand the concept

- A sinusoidal alternating current (AC) varies with time in the form of a sine wave.
- The rms value (root mean square) of AC, denoted as I_{rms} , represents the effective value of current that would produce the same heating effect in a resistor as a direct current (DC) of the same value.
- The peak (maximum) value, I_0 , is the highest instantaneous value the current reaches during a cycle.

For a sinusoidal AC:

- Instantaneous current: $I = I_0 \sin(\omega t)$
- RMS value: $I_{\text{rms}} = I_0 / \sqrt{2}$

Step 2: Use the formula

To find the peak current:

Formula:

$$I_0 = I_{\text{rms}} \times \sqrt{2}$$

Given:

$$I_{\text{rms}} = 10 \text{ A}$$

Calculation:

- $I_0 = 10 \times \sqrt{2}$
- $I_0 \approx 10 \times 1.414$
- $I_0 \approx 14.14 \text{ A}$

Step 3: Explanation of relation

- RMS value is always less than the peak value for a sinusoidal AC.
- The factor $\sqrt{2}$ comes from the mathematical relation between the mean square of a sine wave and its peak.

-
- This relationship is standard for all sinusoidal AC voltages or currents.

◆ **Summary:**

- **RMS current:** $I_{\text{r.m.s.}} = 10 \text{ A}$
- **Peak current:** $I_0 = 14.14 \text{ A}$
- **Relation:** $I_0 = I_{\text{r.m.s.}} \times \sqrt{2}$

This means the current in the circuit varies from -14.14 A to +14.14 A in each cycle.

★ **16.2 Name the device that will (a) permit flow of direct current but oppose the flow of alternating current (b) permit flow of alternating current but not the direct current.**

❖ **Answer:**

(a) Device: Inductor (Choke coil)

- An inductor allows direct current (D.C.) to flow easily because D.C. has zero frequency, so inductive reactance is zero.

-
- It opposes alternating current (A.C.) because A.C. has frequency and the inductor produces inductive reactance which increases with frequency.
 - That is why a choke coil is used to control A.C. without wasting energy.

Key idea (plain text):

- **For D.C.** → frequency = 0 → opposition ≈ 0
- **For A.C.** → frequency > 0 → opposition increases

(b) Device: Capacitor

- A capacitor allows alternating current (A.C.) to pass because the changing voltage causes continuous charging and discharging.
- It blocks direct current (D.C.) because after being fully charged, no further current can flow.

Key idea:

- For D.C. → capacitor gets charged → current stops
- For A.C. → continuous charging/discharging → current flows

◆ Summary:**Inductor (Choke):**

- ✓ Permits D.C.
- ✗ Opposes A.C.

Capacitor:

- ✓ Permits A.C.
- ✗ Blocks D.C.

★ 16.3 How many times per second will an incandescent lamp reach maximum brilliance when connected to a 50 Hz A.C. source?

❖ Answer:

- An incandescent lamp glows due to the heating effect of electric current.
- The brightness of the lamp depends upon the power dissipated in the filament.

For an A.C. supply, the current changes its direction every half cycle, but the heating effect does not depend on the direction of current. It depends on the square of current.

In one complete cycle of A.C., the current becomes maximum twice:

- once in the positive half cycle
- once in the negative half cycle

Therefore, the lamp reaches maximum brilliance twice in each cycle.

Given:

Frequency of A.C. supply = 50 Hz

This means = 50 cycles per second

Calculation:

Number of times lamp reaches maximum brilliance per cycle
= 2

Number of cycles per second = 50

So,

Maximum brilliance per second = 2×50

= 100 times per second

Final Answer:

👉 An incandescent lamp connected to a 50 Hz A.C. source reaches maximum brilliance 100 times per second.

◆ **Summary:**

- Brightness depends on heating effect (I^2)
- Heating occurs in both half cycles
- Maximum brilliance occurs twice per cycle
- At 50 Hz → 100 times per second

☀ **16.4 A circuit contains an iron-cored inductor, a switch and a D.C. source arranged in series. The switch is closed and**

after an interval reopened. Explain why a spark jumps across the switch contacts.

❖ **Answer:**

- **When the switch is closed**, current starts flowing through the iron-cored inductor.
- **Due to the current**, a magnetic field is produced around the coil and energy is stored in this magnetic field.
- **According to the principle of self-induction**, an inductor always opposes any change in current flowing through it.

When the switch is opened:

- As soon as the switch is reopened, the current in the circuit suddenly tends to become zero.
- This sudden decrease in current causes the magnetic field of the inductor to collapse rapidly.
- Due to this rapid change of current, a large induced e.m.f. is produced across the inductor.
- This induced e.m.f. acts in such a direction that it tries to maintain the current in the circuit.

Reason for spark:

- The induced e.m.f. across the inductor becomes very high when the current is interrupted suddenly.
- This high voltage appears across the small air gap between the switch contacts.

As a result, the air between the contacts gets ionized, and a spark jumps across the switch contacts.

Important point (iron core effect):

- Because the inductor has an iron core, its self-inductance is large,
- so the induced e.m.f. is much stronger, making the spark more intense.

◆ **conclusion:**

👉 A spark appears across the switch contacts because a large induced e.m.f. is produced due to self-induction when the current is suddenly broken, which ionizes the air gap and causes sparking.

◆ **Summary:**

- Inductor stores energy in magnetic field
- Sudden opening of switch → rapid decrease in current
- Rapid change in current → large induced e.m.f.
- High voltage across contacts → air ionization
- Spark is produced due to self-induction

★ **16.5 How does doubling the frequency affect the reactance of:**

(a) an inductor

(b) a capacitor

❖ **Answer:**

- Reactance is the opposition offered to alternating current due to inductance or capacitance.
- The effect of frequency on reactance is different for an inductor and a capacitor.

(a) Effect on inductive reactance

- Inductive reactance depends directly on frequency.

Inductive reactance is given by the relation (plain text):

$$X_L = 2\pi f L$$

Where:

- f = frequency
- L = inductance

👉 From this relation, inductive reactance X_L is directly proportional to frequency f .

When frequency is doubled:

If frequency becomes $2f$, then

- $X_L (\text{new}) = 2\pi (2f) L$
- $X_L (\text{new}) = 2 \times (2\pi f L)$

So,

👉 Inductive reactance becomes double.

(b) Effect on capacitive reactance

- Capacitive reactance depends inversely on frequency.

Capacitive reactance is given by the relation (plain text):

$$X_C = 1 / (2\pi f C)$$

Where:

- f = frequency
- C = capacitance

👉 From this relation, capacitive reactance X_C is inversely proportional to frequency f .

When frequency is doubled:

If frequency becomes $2f$, then

$$X_C (\text{new}) = 1 / (2\pi (2f) C)$$

$$X_C (\text{new}) = 1 / (2 \times 2\pi f C)$$

So,

👉 Capacitive reactance becomes half.

Conclusion (capacitor):

- Doubling the frequency
- Capacitive reactance becomes half
- AC current increases

◆ **Summary:**

- **Inductor:** Doubling frequency → reactance doubles
- **Capacitor:** Doubling frequency → reactance becomes half

☀️ **16.6 In a R - L circuit, will the current lag or lead the voltage? Illustrate your answer by a vector diagram.**

❖ **Answer:**

In an R–L series circuit, the current lags the applied voltage because the inductor opposes changes in current by producing a back emf.

Explanation with Equations:

1. Inductive reactance:

The opposition of the inductor to AC is called inductive reactance and is given by:

$$X_L = 2 * \pi * f * L$$

where f is the frequency in Hz and L is the inductance in Henrys.

2. Impedance of R–L circuit:

The total opposition of the series circuit is called impedance:

$$Z = \sqrt{R^2 + X_L^2}$$

3. Phase angle (current lag):

The phase angle between the total voltage and current is:

$$\theta = \arctan(X_L / R)$$

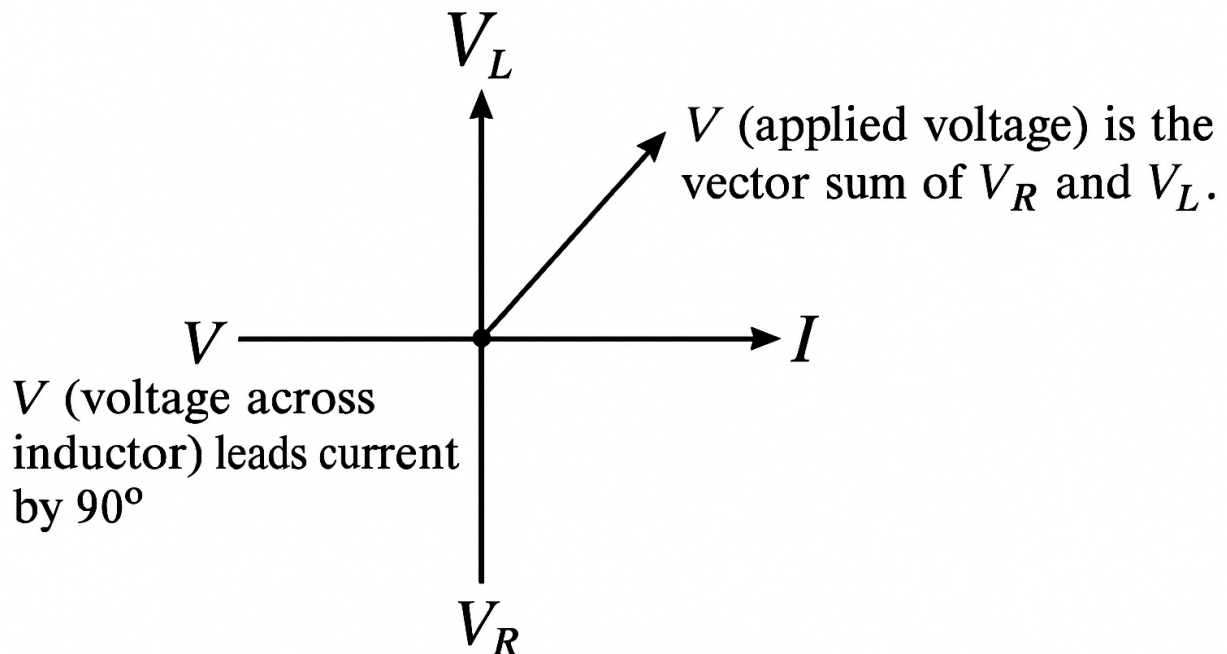
4. Current in the circuit:

The RMS current is given by Ohm's law for AC:

$$I = V / Z$$

where V is the applied voltage.

Vector Diagram (Phasor):



I (current) is taken as a reference.

V_R (voltage across resistor) is in phase with current

◆ Conclusion:

-
- The current lags the applied voltage by the phase angle $\theta = \arctan(X_L / R)$.
 - The lag increases as inductive reactance increases or resistance decreases.

☀ **16.7 A choke coil placed in series with an electric lamp in an A.C. circuit causes the lamp to become dim. Why is it so? A variable capacitor added in series in this circuit may be adjusted until the lamp glows with normal brilliance. Explain how this is possible.**

❖ **Answer:**

1. Why the lamp becomes dim with a choke coil:

- A choke coil is an inductor with high inductance and very low resistance.
- When placed in series with a lamp in an AC circuit, the inductive reactance of the choke opposes the alternating current.
- The AC current flowing through the lamp decreases, and since the brightness of the lamp depends on current, the lamp becomes dim.

Inductive reactance:

$$X_L = 2 * \pi * f * L$$

where L is the inductance of the choke and f is the frequency of AC.

2. How adding a variable capacitor restores brightness:

A capacitor in series has capacitive reactance, which is given by:

$$X_C = 1 / (2 * \pi * f * C)$$

where C is the capacitance.

- The capacitor produces a current that leads the voltage, while the inductor produces a current that lags the voltage.
- By adjusting the capacitor, its reactance can partially or completely cancel the inductive reactance of the choke.

The net reactance of the series combination becomes small:

$$X_{\text{net}} = X_L - X_C$$

With reduced total opposition ($Z = \sqrt{R^2 + X_{\text{net}}^2}$), the current increases to nearly its original value, so the lamp glows with normal brilliance.

◆ **Summary:**

- Choke reduces lamp brightness due to opposition to AC (inductive reactance).
- The series capacitor cancels part of the inductive reactance.
- **By adjusting C**, the lamp current is restored, and brightness returns to normal.

🌟 **16.8 Explain the conditions under which electromagnetic waves are produced from a source?**

❖ **Answer:**

Electromagnetic waves are self-propagating waves of electric and magnetic fields. They are produced under the following conditions:

1. Acceleration of electric charges:

- A stationary charge produces a static electric field, but it does not radiate energy as waves.
- A charge moving with constant velocity produces a steady magnetic field, but again, no radiation occurs.
- Only accelerating charges produce changing electric and magnetic fields that propagate as electromagnetic waves.

Example: Alternating charges in a radio antenna.

2. Time-varying electric and magnetic fields:

- According to Maxwell's equations, a changing electric field produces a magnetic field, and a changing magnetic field produces an electric field.
- These fields regenerate each other and move through space, forming an electromagnetic wave.

3. Presence of an oscillating source:

- A source like an alternating current (AC) in a transmitting antenna provides the oscillating charges required.

-
- The frequency of oscillation of the charges determines the frequency of the electromagnetic waves produced.

4. No medium is required:

- Electromagnetic waves can propagate through vacuum, air, or any transparent medium because they are self-propagating fields.

◆ Summary:

- Electromagnetic waves are produced when electric charges accelerate.
- Changing electric and magnetic fields sustain each other and propagate through space.
- Oscillating sources like antennas generate EM waves of specific frequencies.
- No medium is required for their propagation; they can travel in vacuum at the speed of light.

★ **16.8 How is the reception of a particular radio station selected on your radio set?**

❖ Answer:

The reception of a particular radio station is selected using the tuning process in a radio receiver. This process involves resonance in a tuned LC circuit connected to the receiving antenna. Here is a detailed explanation:

1. Receiving antenna:

- The antenna intercepts electromagnetic waves of many different frequencies from various radio stations simultaneously.
- These waves induce a very small alternating voltage in the antenna.

2. Tuned LC circuit (resonance):

- A coil (L) and a variable capacitor (C) are connected in parallel to form a resonant circuit.

The natural or resonance frequency of the LC circuit is given by:

$$f_r = 1 / (2\pi \sqrt{L C})$$

By adjusting the variable capacitor C, the LC circuit is tuned to resonate at the frequency of the desired radio station.

3. Selection of a particular station:

- At resonance, the LC circuit responds strongly to the desired frequency and rejects other frequencies.
- The voltage across the LC circuit increases, producing a stronger signal for the specific station.

4. Demodulation:

- The selected signal is then passed to a demodulator (detector) which extracts the audio or information signal from the carrier wave.
- This audio signal is amplified and sent to the speaker.

◆ Summary:

- A radio receives many frequencies, but a tuned LC circuit selects one.
- Resonance occurs when the LC circuit frequency equals the station's carrier frequency: $f_r = 1 / (2\pi \sqrt{L C})$.

-
- Adjusting the capacitor allows tuning to different radio stations.
 - The selected signal is demodulated and converted to sound in the speaker.

☀ 16.10 What is meant by A.M. and F.M.?

❖ Answer:

Modulation is the process of impressing a low-frequency information signal (like sound, speech, or music) onto a high-frequency carrier wave so that it can be transmitted over long distances. There are two common types of modulation: Amplitude Modulation (A.M.) and Frequency Modulation (F.M.).

1. Amplitude Modulation (A.M.)

- In A.M., the amplitude of the high-frequency carrier wave is varied in accordance with the amplitude of the modulating signal, while the frequency of the carrier remains constant.
- The modulating signal is usually an audio signal (voice or music).

Key points:

- Carrier frequency stays constant.
- Amplitude changes according to the information signal.
- Typical transmission frequency: 540 kHz to 1600 kHz.

Representation:

- **Carrier wave:** constant amplitude, high frequency.
- **Modulating signal:** low frequency audio signal.
- **Resulting A.M. wave:** amplitude varies in sync with the audio signal.

2. Frequency Modulation (F.M.)

In F.M., the frequency of the carrier wave is varied according to the amplitude of the modulating signal, while the amplitude of the carrier remains constant.

Key points:

- Carrier amplitude stays constant.
- Frequency changes according to the information signal.

-
- Commonly used for high-fidelity sound broadcasting (FM radio).

◆ **Summary:**

- A.M. (Amplitude Modulation): Amplitude of carrier varies, frequency constant.
- F.M. (Frequency Modulation): Frequency of carrier varies, amplitude constant.

Both methods allow transmission of information signals over long distances using electromagnetic waves.

Note:

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

Author: Muhammad Asghar

Purpose: To contribute to education by offering insightful, valuable content that enhances learning and understanding.

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